MICRO 7807

THE BACTERIOLOGICAL WATER QUALITY OF THE BIG EAST RIVER, HUNTSVILLE, 1975 AND 1976.

THE EFFECTS OF WASTEWATER FROM THE KIMBERLY-CLARK TISSUE MILL.

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In 1975, sampling of water was carried out by a field crew supplied by the Technical Support Section M.O.E. Central Region. Water samples were analysed by Andrea Toth, assisted by Patricia Morgan, and John Fodor.

In 1976 water sampling and analysis was carried out by Russ Redshaw, and Darlene Zetts. The Final Report was prepared by George Hendry, Andrea Toth, and Susan Janhurst.

SUMMARY

The bacteriological water quality of the East River in 1975 was poor. The fecal coliform and fecal streptococcus densities exceeded the MOE Recreational Use Criteria in the morning and afternoon surveys and thus indicated a potential health risk for bathers. No specific bacterial inputs were detected and the source of fecal contamination appeared to be of animal rather than of human origin. Pollution from the Kimberly-Clark tissue mill was found to be very low in 1975.

The bacteriological water quality of the East River in 1976 was good with exception of the fecal streptococcus densities. Although no specific bacterial inputs were identified, the fecal pollution present was probably of animal origin and carried in by stormwater. The fecal material was therefore from non-point (diffused) sources.

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DESIGN OF THE SURVEYS

Sampling

Measurement of bacterial numbers over five consecutive days at a sampling location provides a reliable number to be taken to arrive at a sound value of the bacterial density. When many river stations are sampled in this manner a reproducible estimate of the bacteria density in the river is obtained.

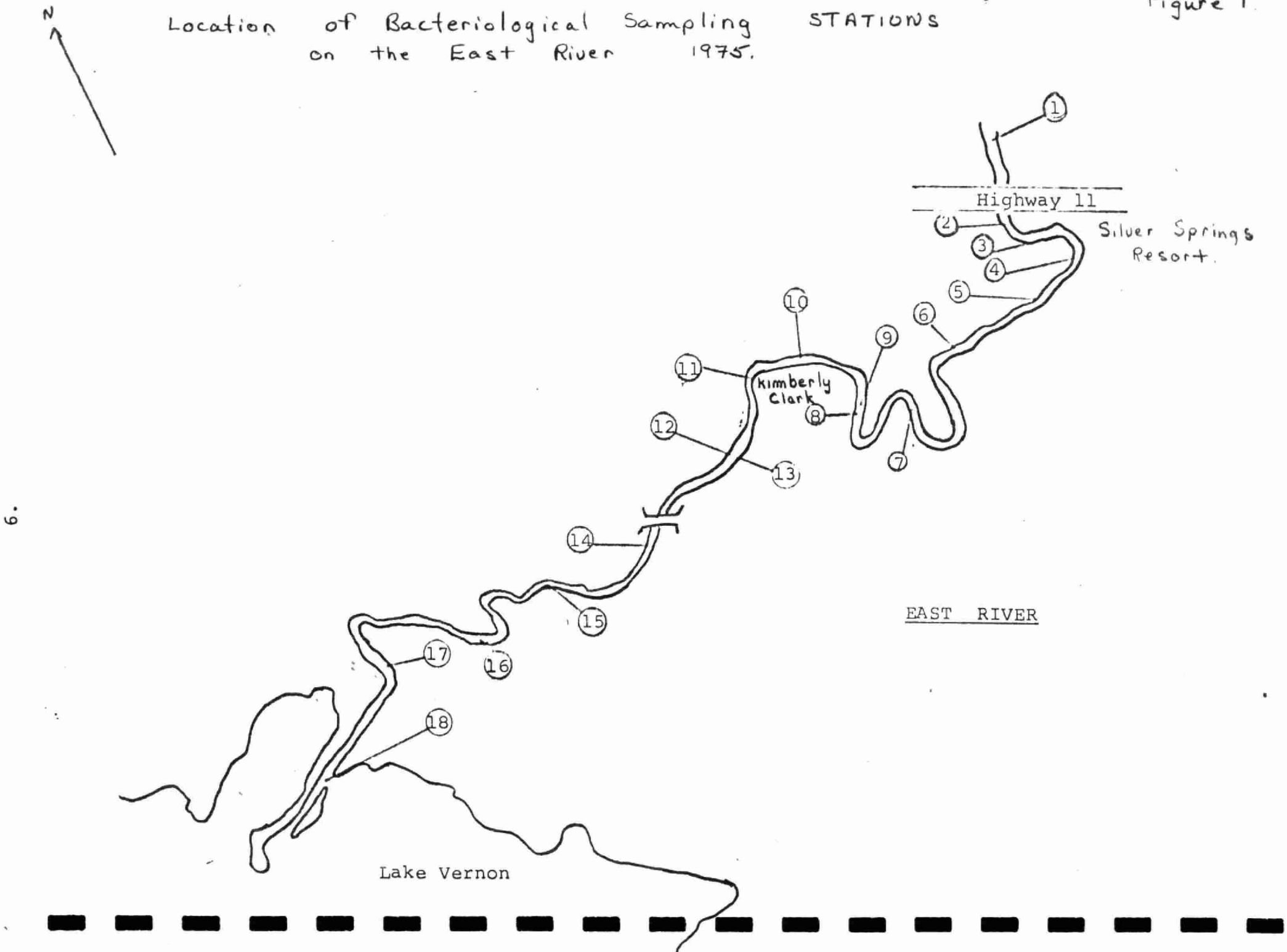
A five-day bacteriological water quality survey was carried out between July 7th and July 11th, 1975. Samples were taken in the morning (9.A.M.) and in the afternoon (2 P.M.). Data was obtained from 90 samples taken from 18 river locations. Seven hundred and sixty bacterial determinations were carried out on these samples.

The bacteriological sampling stations were located at some midriver points, inflows and in areas considered to be representative of the various degree of shoreline development found on the river (Figure 1). The samples were taken one meter below the surface, as well as directly from piped effluents. The water quality of the river was obtained from Highway 11 southward to the outflow into Lake Vernon, which included the river above, at, and below the Kimberley Clark Paper Products plant. Samples were taken in clean sterile 250 ml bottles.

In 1976 the river was surveyed again from July 4th to July 6th. On this occasion the river was surveyed above Highway 11. Forty two samples were taken and 197 bacteriological determinations were carried out.

Figure 1

Location of Bacteriological Sampling STATIONS on the East River 1975.



Bacterial Tests and Interpretation

The density of three 'indicator' organisms was determined on each sample. The three indicators, total coliform, fecal coliform and fecal streptococcus bacteria are all indigenous to man and other warm-blooded animals, and are found in the colon and feces in tremendous numbers. Many diseases common to man can be transmitted by feces; consequently, the probability of occurrence of these diseases is highest in areas where the water is contaminated with fecal material. These indicator organisms in water signify the possible presence of disease causing organisms. The density of heterotrophic bacteria and the pathogen Pseudomonas aeruginosa was also obtained. The heterotrophic bacteria were determined from 4 sampling locations, Stations 4,7,12 and 17. Pseudomonas aeruginosa is found largely in the feces of man and may cause disease when encountered in water. Heterotrophic bacteria are found in the greatest numbers in nutrient-rich waters.

The density of these bacteria in water will vary considerably between samples taken at the same station, or at different stations on a river, or if taken at different times, and so the assessment of water quality cannot be determined accurately from a single water sample. Therefore, the bacteriological surveys require many samples to be taken at several river stations over a period of time. The large amount of data obtained is reduced by calculations to meaningful and easily managed statistics.

These data were then evaluated by statistical techniques in the following manner. The geometric mean, the most appropriate central value, and variance were calculated for the values of each indicator bacterium and Pseudomonas aeruginosa at every station, providing concise valid data. Statistically significant variations in the bacterial densities between stations, or groups of stations,

were determined by a One-Way Analysis of Variance and Bartlett's Test of Homogeneity. By these means, the data from each station were tested against that of every other station until all stations with similar geometric mean densities were separated into groups (Group A,B...).

The group results and those for individual stations were identified by different stippling. Within each stippled area, the group geometric mean applies for each type of bacteria unless otherwise indicated by individual station values. The areas of better or worse bacterial densities were defined by the group geometric mean densities, and so any inputs of bacterial contamination, and the area they affect, were identified.

Bacterial Enumeration

1. Total coliform (TC) bacteria were determined as a count of dark-red colonies with gold metallic sheen grown on a membrane filter (Gelman GN6) with m-Endo LES agar(1).
2. Fecal coliform (FC) bacteria were determined as a count of acid producing yellow to yellowish-green colonies grown on a membrane filter with MacConkey broth at 44.5° C(1).
3. Fecal streptococcus (FS) bacteria were obtained from a count of pink or red colonies grown on a membrane filter with m-enterococcus agar(1).
4. Pseudomonas aeruginosa (P A) were determined as a count of flat, tan to brown colonies grown on a membrane filter with mPA medium(2).
5. Heterotrophic bacteria (HB) were obtained from a total count of colonies from surface inoculated plates of modified Foot and Taylor medium , incubated for seven days at 20° C(3).

Bacterial Identification

Fecal coliforms were identified using the Enterotube system (Hoffmann-LaRoche).

Results

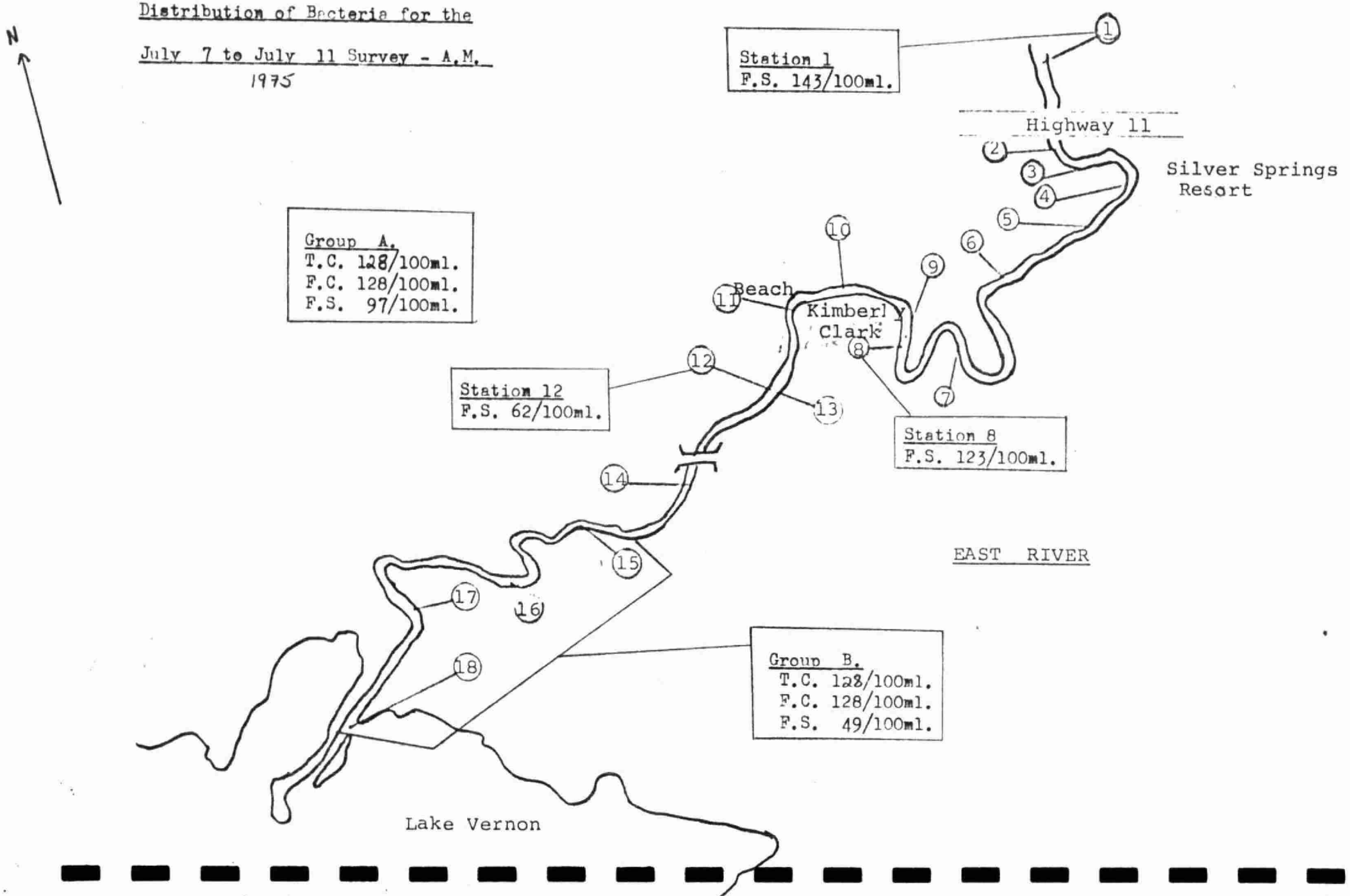
Present Water Quality of the River

In July 1975, the bacteriological water quality of the river in the morning and afternoon surveys was poor. Fecal coliform and fecal streptococcus densities exceeded the Recreational Criteria for total body contact which states:

> "Water should be free from pathogens including any bacteria, fungi or virus that may produce enteric disorders or eye, ear, nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform (TC), fecal coliform (FC) and/or enterococcus (fecal streptococcus, FS) geometric mean density exceeds 1000, 100 and/or 20 per 100ml respectively, in a series of at least ten samples per month,...(4)

In the morning surveys, the main portion of the river had geometric mean bacterial densities of 128 TC, 128 FC and 97 FS per 100 ml (Group A, Figure 2). The lower portion of the river (Group B, Figure 2) had decreased fecal streptococcus densites of 49 FS per 100 ml but total coliform and fecal coliform densities did not differ from the main portion of the river. Near Highway 11 (Station 1) and further downstream at the Kimberly Clark discharge pipe (Station 8) fecal streptococcus densities had increased to 143 and 123 FS per 100 ml respectively. Further downstream near a heavily cottaged area (Station 12) fecal streptococcus levels had decreased to 62 FS/100 ml.

The fecal coliform and fecal streptococcus densities were very high throughout the surveyed area and indicated the presence of fecal pollution, however the pathogen Pseudomonas aeruginosa was not detected. Pseudomonas aeruginosa is a bacterium generally associated with fecal pollution of human origin. Thus the finding of high fecal coliforms with low Pseudomonas aeruginosa levels of less than 1 PA per 100 ml suggested the possibility that the source of fecal pollution was animal rather than human.

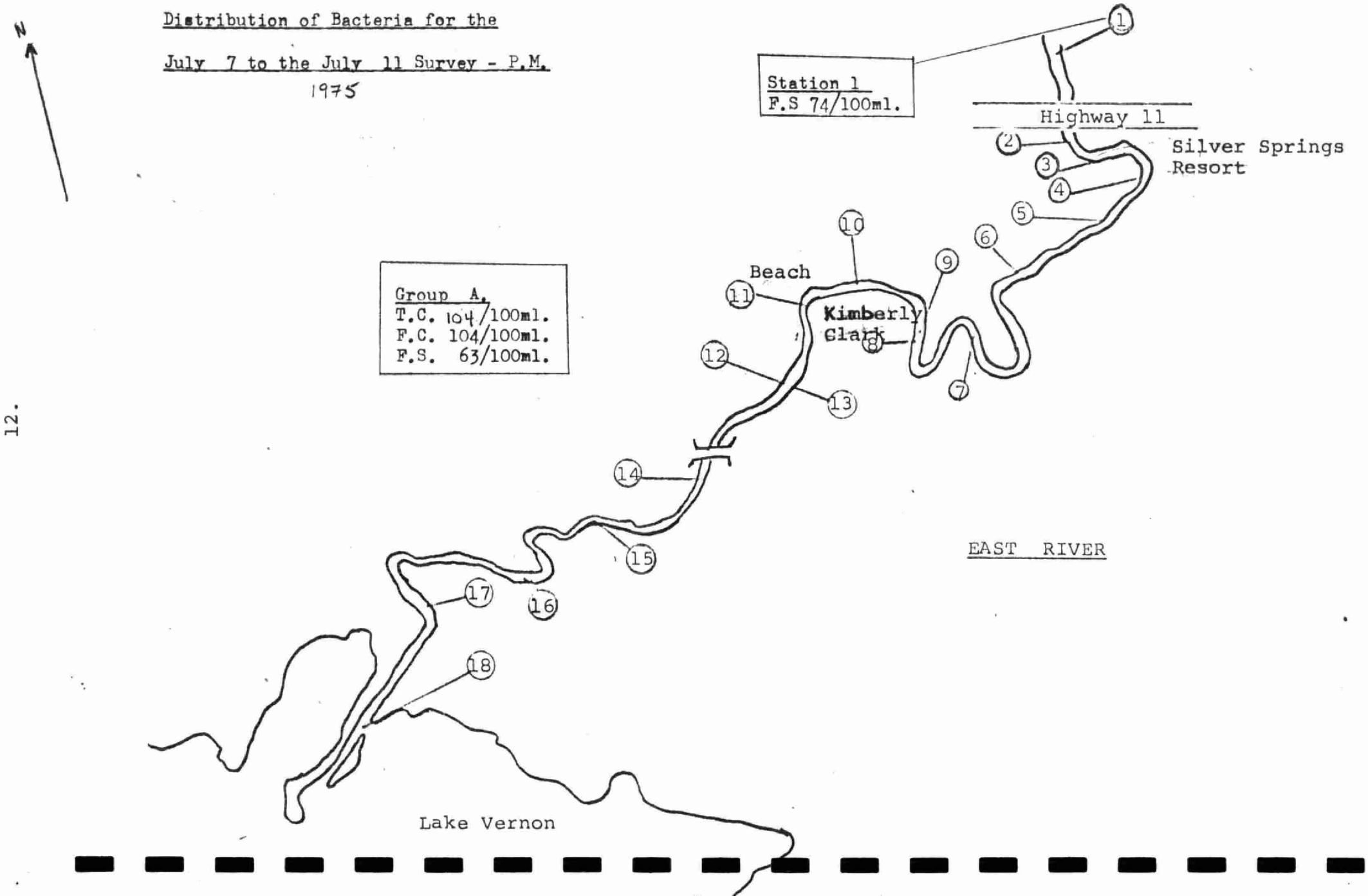

Distribution of Bacteria for the
July 7 to July 11 Survey - A.M.
1975
N
Station 1
F.S. 143/100ml.
Highway 11
Silver Springs
Resort
Group A.
T.C. 128/100ml.
F.C. 128/100ml.
F.S. 97/100ml.
Beach
Kimberly
Clark
Station 12
F.S. 62/100ml.
Station 8
F.S. 123/100ml.
EAST RIVER
Group B.
T.C. 128/100ml.
F.C. 128/100ml.
F.S. 49/100ml.
Lake Vernon

In the afternoon surveys the geometric mean bacterial densities were homogenous throughout the river with levels of 104 TC, 104FC and 63 FS per 100 ml (Group A, Figure 3). An exception however was found near Highway 11 (Station 1) where fecal streptococcus densities rose to 74 FS per 100 ml. The bacterium Pseudomonas aeruginosa was not isolated from the river during this survey. It appeared that the fecal pollution present in the afternoon was also of animal origin.

The geometric mean density of aerobic heterotrophic bacteria in the morning was 678 HB per 1.0 ml and rose to 886 HB per 1.0 ml by the afternoon.

The geometric mean bacterial densities of fecal indicator bacteria for the main part of the river (Group A) were similar for both surveys although a decrease was noted in the afternoon. At this time, the river was homogenous for total and fecal coliforms and fecal streptococcus with the exception of Station 1 (near Highway 11) where fecal streptococcus levels increased. The overall fecal coliform and fecal streptococcus means were very high in these surveys but Pseudomonas aeruginosa was not isolated. These results indicated that the fecal pollution was not of human origin but rather of animal origin which may have been transported by the river water from upstream locations.

The input from the Kimberly Clark tissue mill (Stn. 8) showed a high fecal streptococcus level, 123 FS per 100 ml in the morning which was not repeated in the afternoon. Coliform bacteria are often discharged from pulp and paper mills but were absent from the Kimberly Clark outflow pipe. This input of bacteria was judged intermittent, small, and therefore under control. This may be due to the practice in the mill of recycling 90% of the industrially used water, in conjunction with good water treatment facilities.


Distribution of Bacteria for the
July 7 to the July 11 Survey - P.M.
1975
N
Station 1
F.S 74/100ml.
Highway 11
Silver Springs
Resort
Group A.
T.C. 104/100ml.
F.C. 104/100ml.
F.S. 63/100ml.
Beach
Kimberly
Clark
EAST RIVER
Lake Vernon
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18

There is also no woodroom or pulp manufacturing operation. This situation may be the exception in Ontario rather than the rule. A recent microbiology report has documented bacterial pollution from several pulp and paper mills in Ontario(4).

In 1976 a three day survey was conducted in July further upstream of Highway 11 to detect bacterial inputs. Fourteen bacteriological water samples were taken in the area of the Arrowhead Provincial Park and tested for total coliform fecal coliform and fecal streptococcus. Also 71 fecal coliform isolates were identified using the Enterotube System (Hoffman and Roche).

In July 1976, the bacterial geometric mean densities for the river were 69 TC, 17 FC and 119 FS per 100 ml (Group A, FIGURE 4). Total and fecal coliform densities were lower and fecal streptococcus levels were notably higher than those concentrations found in the 1975 survey.

The identification of 71 fecal coliform isolates in 1976 (Table 1) revealed 67 out of 71 isolates (94.4%) were Escherichia coli, a bacterium that is indicative of fecal pollution. Since no bacterial inputs were detected, fecal coliform and fecal streptococcus densities from cottaged and undeveloped areas were compared. The results indicated that there were no significant differences between the bacterial densities found in these areas. Since there were low levels of fecal coliforms with corresponding high levels of fecal streptococci throughout the river, it followed that the fecal pollution present was probably of animal origin, The fecal material in both years was likely of non-point (diffused) sources.

Distribution of Bacteria for the July 4 to July 6 Survey 1976

Figure 4

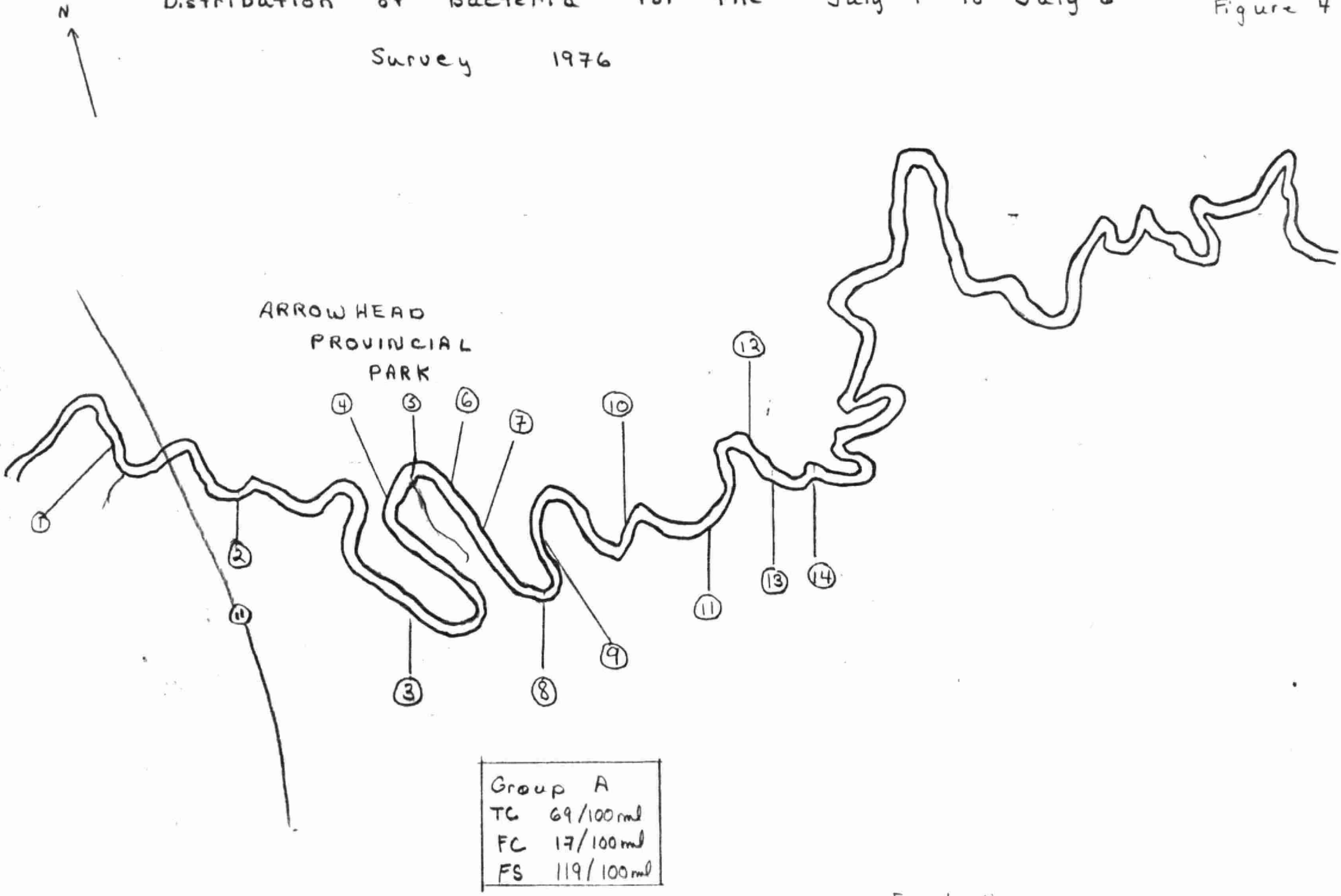

TABLE 1

TYPES OF FECAL COLIFORMS ISOLATED FROM THE EAST RIVER (1976).

Bacterial Type		
E.coli	67/71	=94.4%
Serratia	2/71	= 2.8%
Edwardsiella	1/71	= 1.4%
Enterobacter hafniae	1/71	= 1.4%

Previous Bacteriological Surveys of The Rivers

The East River has been surveyed before by the MOE in 1970 and 1971 and pollution was not observed from the Kimberly Clark plant at that time(6). High fecal coliform levels were found in the East River in 1970. Densities of fecal coliforms in July, 1970 ran as high as 61 FC per 100 ml. The 1975 survey confirmed that high levels of fecal coliforms can be found in the East River from time to time. The porous sandy soil through which the East River runs probably contributed to rapid stormwater runoff and flushing of fecal bacteria into the river from non-point sources.

River Monitoring Data

The East River Was Monitored(5) above and below the Kimberly Clark Mill in 1972 and 1973. There was no significant increase in bacterial numbers below the mill. There was a tendency for the density of total coliform and fecal coliform bacteria to be higher below the Kimberly Clark mill and this may be consistent with a small intermittent pollution source between the two sampling points. The monitoring data (Table 2) therefore confirmed the more intensive survey results. It is recommended that monitoring be continued from time to time since the paper mill is a large potential source of pollution and the receiving waters are valuable for recreational purposes.

TABLE 2

Confirmatory Evidence From Earlier

Water Quality Monitoring Surveys

Geometric Mean (Per 100 ml) of All Annual Data

Year of Survey	Above Kimberly Clark (Hwy. 11)			Below Kimberly Clark (Ravencliff Rd.)		
	TC	FC	FS	TC	FC	FS
1970	-	-	-	35	-	-
1971	-	-	-	122	-	-
1972	83	6	10	96	4	4
1973	39	2	3	129	2	4
1976	190	4	3	446	17	2
1977	97	5	7	116	5	7
Overall GM	85	4	5	112	5	4

NOTE: There were no significant differences between mean values at either location or between mean values for each year at the same location.

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5) Water Quality for Ontario Lakes and Streams. Vol. VI to IX, 1970-1974, Water Resources Branch, Ontario Ministry of the Environment.

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